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Hearing Aids

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Hearing Aids

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Preface

This publication contains information, useful to the hard of hearing, on several topics relating to hearing and hearing aids. We assume that you have already consulted a physician on the diagnosis of your hearing loss, for this is the necessary first step in correcting any faulty hearing condition. The publication may also be of interest to teachers and others wishing to explore this field.

For a number of years the National Bureau of Standards has been active in studying the properties of hearing aids — largely for such Government agencies as the Veterans' Administration. To aid in answering inquiries on the selection of such devices, a mimeographed leaflet (NBS Letter Circular 945) was issued in 1949. In 1951 Circular 516, "Selection of Hearing Aids," based on the Letter Circular was issued. In March 1953, a revision of Circular 516 was issued: the contents of the two circulars were substantially the same although some minor changes had been made, including several suggested by manufacturers of hearing aids. Circular 534 has been out of print for some time. This publication has been revised extensively; some of the new material is based upon our own research during the intervening years.

Contents

Hearing Aids

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This publication represents an extensive revision of NBS Circular 534, Hearing Aids. It includes new material based upon research conducted at the National Bureau of Standards during the intervening years.

Key words: Audition; communications; hearing; hearing aids; selection of hearing aids; speech communication.

1. Introduction

Loss of hearing creates a serious problem. For most of us, the spoken word is our most important channel of communication. Even slight losses can interfere with participation in public affairs, and it does not take a very high degree of loss to hamper a person in conversation within a group.

If you have difficulty in hearing speech in a group conversation, you may find that wearing a hearing aid makes it easier for you to carry on your daily affairs. Even if you are one of the many people who have difficulty only with faint speech, you may be considered as a "marginal" hearing aid user. Your hearing loss may hinder you only in public places—at lectures, meetings, and the theater. A hearing aid would still be of decided assistance. The instrument need not be very powerful. On the other hand, because persons with a slight loss can make direct comparisons between their unaided hearing and that with an instrument, you may tend to be quite critical of the acoustical qualities of the hearing aid.

A person in need of a hearing aid has a special problem, for he himself must decide which instrument gives him the greatest benefit. Hearing aids cannot at present be fitted to individual hearing losses with the same exactitude as eyeglasses can be fitted to the refractive imperfections of the eye. We know that one reason for this lack of precision is the variety of factors causing hearing loss. A loss in hearing can occur either because the cochlear nerve has become insensitive or because the sound vibrations are conducted inefficiently from the outer to the inner ear. Each of these conditions produces a hearing loss that behaves in a distinctive manner. Loss of hearing is often due to a combination of these causes in various proportions; it is not easy to measure the proportions.

Since the earlier Circulars were published, we have had a number of years of experience with the conventional tests that also are applied to other speech communication systems such as telephones and public-address systems. These systems are designed for normal listeners. The results of conventional tests do not predict the performance of hearing aids in service to the degree we should consider definitive. Significant exceptions have been found in which a hearing aid having "defective" performance as measured by the conventional tests has proved better in service—not alone in listener preference, but in actual speech transmission—than a hearing aid that seemed to offer superior physical performance.

Some years of rueful experience reinforce our original remarks: The effectiveness of a hearing aid with known physical characteristics can be predicted only in a general way. You must pay close attention to the selection of your own hearing aid if you wish to be well fitted.

Sections 3, 4, 5, and 6 describe the important properties of hearing aids, some of the criteria for judging them, and recommendations for their special care. To judge a hearing aid and to understand its limitations, it is helpful to consider the properties of sound and hearing that influence the performance of hearing aids. Section 2 contains a brief sketch of this background.

2. Some Properties of Sound and Hearing

The origin of the sensation of hearing is always some kind of energy. The most usual path through which hearing is stimulated starts with periodic pulsations of pressure in the air around us. These pulsations of pressure enter the outer ear and travel down the ear canal. They induce a to-and-fro motion of the drum membrane. Attached to the inner side of the drum membrane is a little chain of bones, so anchored that they take the relatively free flexible movement of the eardrum and convert it to small but very forceful motions of the fluid that fills the inner ear, or cochlea. (Cochlea is the Latin word for "snail"; the fluid chamber in the inner ear is coiled into a tight little spiral.) Within the cochlea, the fibers of the cochlear nerve end in contacts with numerous tiny structures

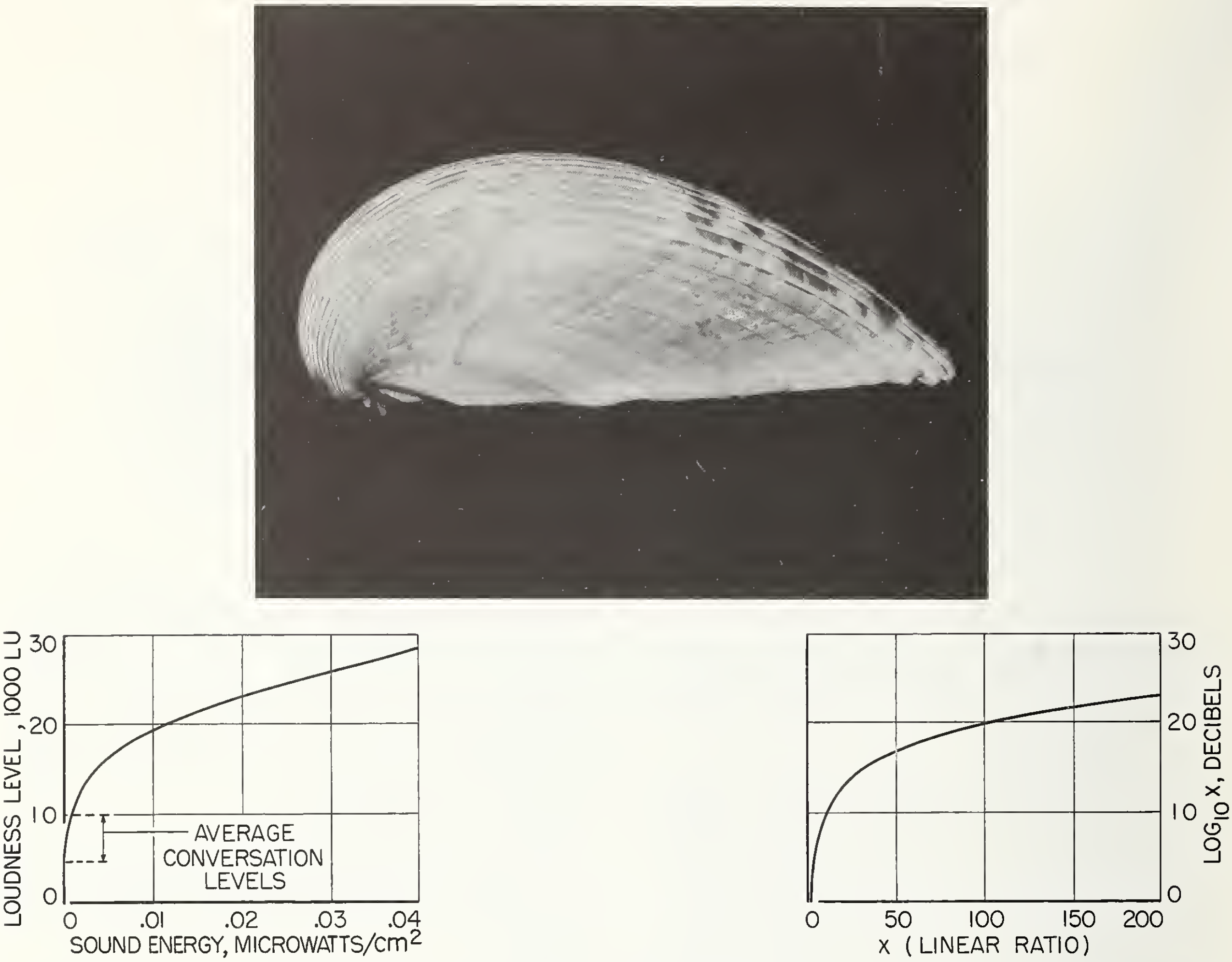

FIGURE 1. *As the curve at the left shows, if the power of a sound is increased, the sensation of loudness perceived by a listener does not increase as rapidly as the increase in power.*

The curve at the right shows that the logarithm of a number has much the same property. These curves show that the decibel scale, which is logarithmic, is directly related to loudness. The logarithmic scale is natural — as is shown by the profile of the sea shell (center). The animal must grow in such a way that it retains its shape, so that it continues to fit into the older part of its shell. Growth must therefore be distributed in proportion to the size of the creature already there, the shell thus forms a logarithmic curve.

called hair cells. The periodic motions of the fluid surrounding the hair cells give rise to electrical signals in the cochlear nerve. The signal ultimately reaching the brain is electrical.

Experiments have been made in which electrical signals applied to electrodes on the head produce the sensation of hearing. The conditions under which this can be done are so special that the method is not at present adaptable for hearing aids. In fact, there seems to be no way known at present to code the electrical signals externally in the same way as they are coded by the inner ear. However, these experiments do show that the ear must translate sound pulses into electrical energy. On animals, it has been possible to measure the electrical signals sent out by the inner ear to the brain when ordinary air-borne sound is applied to the ear. In the type of hearing loss called a "nerve" or sensorineural loss, either the inner ear mechanism no longer converts the motion of the fluid efficiently into electrical power, or the cochlear nerve simply does not carry the electrical signals to the brain. An interesting and mystifying quality of nerve loss is that it sometimes acts as though a steep barrier had been placed in the path of hearing. Sounds that have enough power to override the barrier may appear almost as loud to the person having a sensorineural loss as they do to a person with normal hearing. This effect is called "Recruitment."

Another form of "sensorineural" loss is a general loss in efficiency, in which even amplified sounds are not heard with adequate precision. A person who exhibits the phenomenon of "recruitment" resembles a normal individual attempting to hear sounds in a noisy environment; he can discriminate sounds clearly if they are sufficiently intense, provided they are not so intense as to confuse his ears. Not so the person suffering from a nerve defect whose ear fails to "recruit." He has a continuing problem in resolving sounds. He may

manage to understand speech when he is in a quiet environment, but in the presence of even a small amount of noise he may be unable to distinguish words.

If the drum membrane or the bones in the middle ear are defective, they are unable to transmit motion to the fluid in the inner ear efficiently. The resulting impairment in hearing is called "middle-ear", or "conductive", loss, because the bones in the ear do not conduct sound very well. A person having this type of loss can use two alternative types of hearing aids. He can use a hearing aid that will supply, by means of an earphone, sound pulses of increased power to his drum membrane, so that even though the middle-ear mechanism is defective, the fluid in the inner ear is set into sufficient motion. Another type of hearing aid bypasses the eardrum altogether. It moves the bones of the skull by means of a vibration device, called a "bone conductor." The motion of the skull induces motion in the fluid of the inner ear, and the sensation of hearing is produced. The bone conductor is employed where use of an earphone is precluded, and is sometimes preferred to an earphone. However, at least at present, earphones are fitted in most conductive losses because they are more efficient.

Moreover, several surgical techniques have been developed that are quite successful in reducing the degree of purely conductive hearing losses. For persons whose cochlear nerve is unimpaired, it is possible in many cases for surgery to mitigate the need for a hearing aid. That is why it is so important to obtain a good medical diagnosis whenever possible, before proceeding to acquire a hearing aid.

We are accustomed to hearing our own voices—in part, at least—through the bones of the head. The quality of the sound transmitted through the head is usually rather different from the sound transmitted through the air. As a result, recordings of our own voices sound strange to us, though each person can recognize his friends' voices from the recording. Because the sounds of their own voices reach them through the bones of the head rather than through the middle ear, persons with a "conductive" loss often have little difficulty in hearing themselves speak.

A tremendous range of energies will produce audible sound. The loudest sound to which the ear can be exposed without injury has about 1,000,000,000,000 times the energy of the faintest sound that can just be heard. Our experience tells us at once that the ear must use a scale different from that on which these numbers have been written down. You do not judge a very loud sound to be nearly a million million times as loud as the faintest sound you can hear.

The rate at which the sensation of loudness increases with sound power is most nearly proportional, not to the total amount added, but to the size of the amount added in comparison to the sound power already present before the addition was made. Everyone agrees that three violins playing together sound louder than one. Suppose you want to double that increase in loudness. It is necessary to persuade more than six violinists to play in unison—you need nine, each playing at the same intensity as the original player. Unless the solo violinist is playing very softly, the problem of producing a sound several times as loud soon exceeds the resources of a symphony orchestra.

The sense of hearing follows a scale that is widespread in nature. The same scale describes such diverse things as the rising of bread dough, the spread of epidemics, and the shape of sea shells.

In figure 1 (left) the curve of loudness is plotted against equal increases in sound power. Notice that as you move to the right on the horizontal scale (increasing power), the vertical distance representing increased loudness becomes smaller for equal increases in power. To a close approximation, the increase in loudness is proportional to the ratio that the sound power added bears to the total power present. The scale that deals with increases proportional to the amount already present turns out to be a rather familiar one. Mathematicians call it a logarithmic scale. Loudness is therefore nearly proportional to the logarithm of the sound power, and in estimating loudness the ear acts on a logarithmic scale. The relation of this scale to the ordinary number scale that we see on rulers and yardsticks—the "linear" scale—can be shown by a line drawn on a graph, as in figure 1 (right). In the horizontal direction, equal distances along the scale are proportional to the ordinary number scale. In the vertical direction, equal distances along the scale are proportional to the common logarithmic scale, which expresses the numbers in terms of the number of times (whole or fractional) that the base number 10 must be multiplied by itself in order to give the ordinary number. This curve has much the same profile as the loudness-power graph. Squaring the ordinary number always doubles the logarithm, and cubing triples it.

The logarithmic relation between the loudness sensation and the sound power is the reason the sound power engineers use the decibel unit. A change of one decibel in sound level is about the difference in loudness between four and five violinists playing in unison. This is about the smallest difference a careful listener can detect.

Describing hearing loss in decibels gives the ratio between the least sound that a person can hear and the normal threshold. Thus, the sound that can just be heard by a person with a 20 decibel hearing loss has 100 times the power of the sound at the threshold for a person with normal hearing; correspondingly, a hearing loss of 40 decibels means that the threshold power required is 10,000 times as great as that for normal hearing. A scale of degrees of hearing loss in decibels is given in appendix 1.

In addition to loudness, we perceive two other properties in a sound: pitch and quality. Pitch is the word used to describe how low or how shrill a sound is. The sensation of sound is produced in our ears by periodic pulsations of pressure in the air around us. Although it is affected by loudness to some minor extent, the pitch of a sound depends primarily upon the rate at which the pulsations occur. This rate, the "frequency" of the sound, is usually expressed in hertz, abbreviated Hz, (i.e., the number of pulsations per second). Here, again, there is a logarithmic behavior in the ear.

Doubling the frequency changes the pitch we perceive by what we recognize as one octave. To the ear there is as great an interval between 100 and 200 Hz as between 2,000 and 4,000 Hz—one octave in each case. The frequency range of pulsations giving rise to auditory sensation extends from 30 Hz to about 15,000 Hz.

From the quality of their sounds, we recognize at once the difference between a tin whistle and a flute. It turns out, upon investigation, that the sounds of a whistle, though of the same apparent pitch as those of a flute, have an admixture of pulsations of higher frequency than the base tone that determines the pitch. It is the composition of this mixture that we recognize as the quality of the sound.

There is a property related to sound that is often important in the consideration of hearing aids. That property is called "resonance." It describes the ease with which objects are set into sympathetic motion by the rhythmic pulsations of the sound. If the object has a natural mode of vibration (in which it would vibrate by itself if set off) that is of nearly the same frequency as the pulsations in the sound, it may vibrate strongly in sympathy with the sound. A system that is easily set into large motion at its natural frequency is described as "highly resonant." On the other hand, if energy is absorbed by friction, so that the sympathetic motions are limited in extent and duration, the system is said to be "damped."

Of course, the increase of response due to resonance is not a case of "something for nothing." The building up of the resonant response and its decay require a period of time. This response time changes the time scale in speech sounds, and has been found to have an important effect on their recognition. If the resonance is strong enough, it alters the duration of sounds within its range, and they become indistinguishable.

3. General Properties of Hearing Aids

A hearing aid is simply a personal public-address system. It has a microphone to pick up sounds, an amplifier to supply additional power, and an earphone to transmit sound to the ear. Its performance is the result of a number of factors, some of them primarily related to the ear and the brain of the user.

A person with impaired hearing has the right to demand from a hearing aid something more than bare intelligibility. Actually, the brain is capable of piecing together an entire idea from mere fragments of speech sounds. As a result, an individual whose hearing loss is not severe probably can hear and understand speech with almost any hearing aid on the market. This does not mean that he will find it effortless or pleasant. However, at best he can describe the hearing aid characteristics he desires only in a general manner, as a pleasing or "natural" quality of the transmitted sound. Or he may note that it is easier to hear through some hearing aids than it is through others.

The following discussion describes some of the characteristics of a hearing aid that are directly related to the "something more" in the relationship between the user and his hearing aid. It is only the listener himself who can determine which factor has the most weight in his particular case.

The "gain" of a hearing aid is its fundamental property. Gain represents the relative increase in power that a hearing aid produces in the sound it transmits. If there is a hearing loss, only a small fraction of the sound signal striking the unaided ear reaches the sensory organ in the brain. The hearing aid builds up the sound energy reaching the inner ear until it yields auditory sensation. The gain is a numerical measure of the extent to which the sound energy is built up, or "amplified."

The gain of a hearing aid is not as a rule independent of the frequency of the sound signal. However, if the instrument is to function as an aid, it must have a useful amount of gain for sound signals in the frequency range important for speech. Most speech sounds occupy the range between 150 and 6,500 Hz. Certain parts of this range are particularly important for the reproduction of speech sounds. The distribution of speech sounds, in frequency and sensation (loudness) level, is shown in figure 2. No sounds

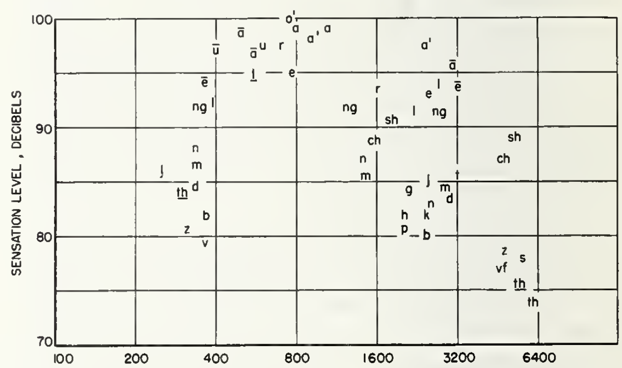

Figure 2. *This chart shows how the sounds that make up ordinary speech are distributed both in frequency and in relative loudness.*

For instance, we can see that the "*d*" sound has important frequencies around 350 Hertz (vibrations per second), and also around 3,000 Hz. Unless a hearing aid reproduces these frequencies, the "*d*" sound will not be clearly heard. The height of the "*d*" symbols in the chart shows that they are ordinarily spoken with medium loudness compared with other consonant sounds. (Chart from *Speech and Hearing*, by Harvey Fletcher of Bell Telephone Laboratories. Copyright 1929, by D. Van Nostrand Company, by permission of Van Nostrand Reinhold Company, New York, New York.)

necessary for understanding speech occur in the frequency region below 200 Hz. As the figure shows, many consonant sounds will be suppressed by hearing aids that do not respond to sound in the upper part of the speech frequency range. The majority of the sounds that give speech its distinctive characteristics lie in the frequency range between 1,000 and 3,000 Hz. The older carbon hearing aids, dependent upon resonant microphone and receiver diaphragms to increase their efficiency, were tuned to favor this frequency range. With these instruments, speech can be understood, but many individual vowels and consonants will not be clearly identified.

The curves shown in figure 3 are acoustical gain curves measured on several representative makes of hearing aids. Some idea of how speech sounds through them can be obtained by considering what it would be like if the gain curves were traced over the phoneme [A phoneme is a discrete part of a speech sound.] chart in figure 2. The hearing loss of the user is, however, an additional factor involved in the performance of a hearing aid in service.

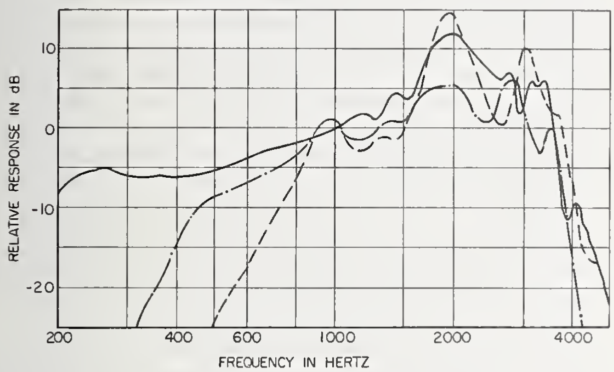

FIGURE 3. *These curves show the acoustic gain, or amplification, of individual hearing aids.*
The instruments were of representative makes. The solid line shows the amplification provided by a body-worn aid that provides a uniform, broadband gain. The dashed line and the dotted line show the gains for two over-the-ear instruments. Amplification of all the instruments is about the same in the middle frequency range, but differs considerably at higher and lower frequencies.

In general, a young or middle-aged person with the type of hearing loss caused by failure of normal conduction of sound to the inner ear can expect good results from a hearing aid. However, if the inner ear itself has become insensitive (as it frequently does in elderly persons and sometimes in young persons), it may not be possible to obtain satisfactory results from a hearing aid.

Ideally, a person using a hearing aid should hear sounds with the same loudness and tone quality as those heard by a listener with unimpaired hearing. In practice, quite a few compromises must be made. A hearing aid cannot provide hearing if the cochlear nerve is inactive; it can only amplify sounds for which the user has some cochlear nerve perception, however insensitive. In some cases of nerve impairment, sounds when heard at all are perceived to be loud. They may appear as loud to the person with nerve loss as they do to an individual with no hearing loss. But a person who has a hearing loss must wear a hearing aid to enable him to hear sounds he could not hear without the aid. When the sound is amplified to a high level, the intense sound put out by his hearing aid may be intolerably loud to the person suffering from nerve loss, and he may choose to do without the aid.

A listener recognizes large variations of the hearing aid gain with frequency as a "distortion" in the transmitted sound. If the combination of his hearing loss and the gain of the hearing aid results in sudden large changes in compensation near a particular frequency or set of frequencies, sounds occurring near those frequencies will appear to be changed in their characteristics—e.g., the tapping of heels on a floor may sound metallic or thumping. Under such circumstances, some sounds may become difficult to recognize. This type of distortion is commonly called frequency distortion, because it results from inadequate frequency range or from too-sharp variations of gain with frequency.

If the range of frequencies over which the gain is uneven is quite narrow, another feature of the "resonance" effect occurs: the time scale of speech and noise sounds is altered by the fact of the resonance, and they become more nearly alike. In some hearing aids showing pronounced resonances, many listeners have no trouble recognizing speech under quiet conditions, but find it difficult to understand speech if noise is also present. A typical comment describing the property of this hearing aid is that it is "noisy," although in terms of physical measurements it may not show any unusual quantity of electrical noise in its output. Noise generated by stroking the outer case of the instrument is not one of the conventional tests, but it is likely that in the presence of resonance it contributes to the listener's overall impression of noise.

Resonance creates another problem. Acoustic feedback from the earphone to the microphone of the hearing aid can occur as a result of amplification of sound leaking from the earmold to the microphone of the hearing aid. The result of this feedback is to generate a steady whistle, usually of a pitch corresponding to the frequency at which the resonance is greatest. Often, in high-powered hearing aids required by persons with a severe hearing loss, it is the generation of this whistle that limits the amplification that can be made available to the listener. Thus, another advantage of freedom from resonance is the opportunity to provide higher overall gain for persons with severe hearing loss, before feedback becomes the limitation.

Another type of distortion may have serious effects upon the sound transmitted by the hearing aid: when the sound level is too high for the power handling capacity of the hearing aid, the excess sound energy is converted by the overloaded instrument into sounds of extraneous frequencies. Overload distortion appears to a listener as a noisy blurring of loud speech sounds.

Both frequency and overload distortion in a hearing aid result from the compromises made in order to satisfy the demands for compactness and economy. Some hearing aids are built with microphones and earphones tuned to resonate in the middle of the speech frequency range. This is done to gain battery economy at the expense of uniform amplification, since uniform amplification over a wide frequency range is attained by heavily damping the natural resonances of the microphone and receiver, thus reducing their efficiency. Speech transmitted over a resonant system may sound tinny, but it will probably be intelligible under quiet conditions.

Earphones have generally less power handling capacity when their size is small. Overloading due to

small size is most likely to occur at the lower frequencies, introducing overtones in the output sound that blur the sounds of higher frequencies that are important for the recognition of words.

An ear mold that fits properly is necessary for best performance from a hearing aid. The ear mold provides a speaking tube leading to the eardrum of the user from the earphone. If it is too loose, sound energy is lost through leakage. The sound energy escaping may be sufficient to reach the microphone of the hearing aid. When this happens, the hearing aid will "squeal" on loud sounds, and it may even squeal continuously. A hearing aid may, in fact, squeal at a frequency inaudible to the user, and he may be aware of the occurrence only because of high distortion or reduced gain.

4. How to Judge a Hearing Aid

In a general way, certain qualities of the sound transmitted to a user's ear by his hearing aid indicate how well his hearing is being compensated for loss. If, without reading lips, he can hear what is said but has some difficulty in recognizing which person is speaking to him, his aid provides insufficient compensation at low frequencies. If, on the other hand, he can recognize the speaker's voice but cannot tell what is being said, the aid does not offer enough compensation at high frequencies. If speech of low intensity is intelligible but loudly spoken words are blurred and noisy, the hearing aid is being used at amplifications greater than those for which it is designed. For higher amplification, it is preferable to use a more powerful instrument. An occasional person with nerve loss may notice this effect with all hearing aids. In this case, however, the distortion arises within his own ear rather than in the hearing aid.

Blurring of loud sounds may also be noticed in a hearing aid in which some part is wearing out, or when the batteries become weak. If a hearing aid that has not overloaded previously on loud sounds begins to do so and the insertion of a new battery does not remedy the condition, the hearing aid may be in need of repair.

When components with natural resonances are present, the amplification is much greater in the immediate neighborhood of the resonant frequencies. As a result, sharp sounds such as heel clicks, drum beats, or typewriter tapping, acquire a musical ringing quality. Certain speech sounds will also be affected by the resonances and will be accompanied by a ringing overtone in the transmitted sound. This may affect the intelligibility of the transmitted speech. The effect of the resonance will be particularly noticeable if there is noise present that can excite the resonance. Because the resonance colors both the speech and the noise with its own dominant characteristics, the impression produced is that the speech has faded into the noise to a greater extent than one would expect purely from listening to the noise itself. And, in fact, it becomes fairly difficult to extricate the speech from the noise. A hearing aid that affords uniform amplification over a wide frequency range will transmit sharp sounds with their unmusical and incisive character unaltered. Because noise present will not be colored by the resonance to resemble the speech, the ability to resolve the speech in the presence of noise will be preserved.

A person who has unimpaired hearing can locate the direction from which sounds are reaching him because his two ears are independent and located at a distance from one another. A similar effect can be achieved when two separate hearing aids are worn, with the sound from each microphone led to the corresponding ear. However, even at the present time, although hearing aids are quite small, most persons use a single hearing aid. The part of the hearing aid that picks up sounds (the microphone) is worn at one point on the body. With a single microphone, directions from which sounds originate cannot be recognized directly, although by moving about one might recognize from changes in the character of the sound that there is a preferred direction. Thus, the use of a single instrument increases the interference produced by extraneous noises, since the listener cannot restrict his attention to sounds from a particular direction.

Now that many persons wear hearing aids on the side of the head, as in an eyeglass, over-the-ear or even in-the-ear fitting, techniques have been worked out for reducing the problem of head shadow. The arrangement is called CROS (Contralateral Routing of Offside Signals). It is most often fitted when a person has fairly good residual hearing in one ear. A microphone is placed beside the poor ear, and the amplified signal is routed to the good ear. If the ear is good enough, an open earmold is used, so that sound reaches the good ear directly, and is combined with the amplified sound from the CROS-fitted microphone. It is also possible to supply amplified sound to the good ear from microphones located at both ears.

Tone controls are provided on some hearing aids to enable the listener to adjust the gain characteristics to suit himself. Such controls operate by reducing the amplification at lower frequencies or, sometimes, at both the low and high extremes of the frequency range. Sometimes they are suggested as a means for reducing background noise. Their use may be indicated by the following hypothetical illustration: suppose that one wants to increase the amplification but discovers that increased amplification creates an unpleasant reception because of noise in the higher frequency range; then by cutting the gain in this region by use of the tone control one may be able to increase the volume without the higher frequencies. It should be remembered, however, that reducing the gain at some frequencies—particularly the higher—reduces the amount of information the user gets, and the higher frequencies are particularly important in speech.

A hearing aid cannot discriminate between pleasant and unpleasant sounds. Over the same range of frequencies in which desired sounds occur, there are many irritating noises that cannot be shut out. The screeching of a hinge and the scraping of a fingernail occupy the same frequency region as do the consonant sounds essential for the recognition of words. More-

over, what may be called the "annoyance factor" of sounds is greater at higher frequencies. A person who has for years suffered a progressive loss of high-frequency hearing is therefore likely to find his first experience with a hearing aid somewhat dismaying. If it will enable him to comprehend speech, he will also rediscover the squeaks and clatter previously screened from him by his own diminished hearing. Almost any one inured to the semisilence of hearing loss may require some time to become readapted to loud sounds. Sensitive individuals may need several months or more to become accustomed to fuller hearing. Eventually most users of hearing aids come to overlook the inevitable noises for the sake of hearing speech with ease.

There are several tests that an individual can use to assist him in deciding whether he is getting the most help from his hearing aid. An inexact but very practical method for finding out how it behaves is to make an articulation test.

An articulation test is based upon the idea that the primary purpose of a hearing aid is the communication of speech. It is simply a refined method for talking to a subject and determining how much of the speech he can understand. Because understanding is involved, ordinary words common to everyone's daily life must be used. An attempt is made to choose words that represent a good sample of the sounds that make up speech. A set of such word lists, the PB or "phonetically balanced" word lists, has been developed at the Psycho-Acoustic Laboratory of Harvard University.

Two of these PB word lists are given in Table 1. One list suffices for a single test, but smaller parts of a single list will not be adequate, because all the speech sounds will not be tested in their proper ratio. To avoid the effects of memory, the words should be copied on cards so that they can be presented in random order. A person who is trying out a hearing aid should get a friend to make this test with him. He should not face the reader, in order that lip reading will not affect the result. The most favorable position is for the reader to be diagonally at one side from the listener so that his face is just removed from the listener's direct line of sight. Interposition of any large obstacle between the reader and the microphone of the listener's instrument should be avoided in the test.

The presentation of the words should be done carefully. To present them naturally, they should be spoken in a sentence in a normal conversational tone. The sentence must be chosen so that the test words cannot be inferred from the rest of the sentence. A carrier sentence commonly used is "You will say * * * now." This sentence has the advantage that the "a" sound in "say" is a high-level sound and can be used by the speaker for checking on his voice level. The sentence should be spoken at ordinary conversational level.

It is unlikely that the person making the test will get 100 percent of the words correctly. Even under ideal communication conditions (with two persons in the same quiet room, but not facing each other) the random word articulation scores are usually 95 percent. Apparently, individuals with normal hearing actually judge the remaining 5 percent of the words in

TABLE 1. *Word lists for articulation tests*

PB-50 List 1		PB-50 List 2	
1. ache	26. muck	1. bath	26. neat
2. air	27. neck	2. beast	27. new
3. bald	28. nest	3. bee	28. oils
4. barb	29. oak	4. blonde	29. or
5. bead	30. path	5. budge	30. peck
6. cape	31. please	6. bus	31. pert
7. cast	32. pulse	7. bush	32. pinch
8. check	33. rate	8. cloak	33. pod
9. class	34. rouse	9. course	34. race
10. crave	35. shout	10. court	35. rack
11. crime	36. sit	11. dodge	36. rave
12. deck	37. size	12. dupe	37. raw
13. dig	38. sob	13. earn	38. rut
14. dill	39. sped	14. eel	39. sage
15. drop	40. stag	15. fin	40. scab
16. fame	41. take	16. float	41. shed
17. far	42. thrash	17. frown	42. shin
18. fig	43. toil	18. hatch	43. sketch
19. flush	44. trip	19. heed	44. slap
20. gnaw	45. turf	20. hiss	45. sour
21. hurl	46. vow	21. hot	46. starve
22. jam	47. wedge	22. how	47. strap
23. law	48. wharf	23. kite	48. test
24. leave	49. who	24. merge	49. tick
25. lush	50. why	25. move	50. touch

ordinary conversation by familiarity, context, or lip reading.

By noticing the particular speech sounds that are missed by the listener in writing down the word list, and comparing them with the chart in figure 2, it is possible to get some idea of the particular way in which the hearing aid fails to compensate for hearing loss.

Perhaps the simplest way for determining whether a hearing aid has a resonance is to listen to footsteps or a typewriter and notice whether a particular note seems to be favored. If there is access to a piano, the resonance can be found by having someone play through the keyboard range several times with a uniform touch. If the hearing aid gain is uneven, certain notes will sound markedly louder or softer than the rest. Experimentation shows that peaks can be detected in this way if they are greater than 20 decibels in magnitude.

In general, the presence of competing noise is a critical test of the performance of hearing aids. Problems with overload and resonance become strikingly evident when noise is present to be mixed with the speech. You should try your prospective hearing aid under noisy conditions as well as in the quiet.

Occasionally you may find a hearing aid that picks up hum from power systems and fluorescent lights. Even though you may have no fluorescent lights in your house, they often are used in restaurants and stores. This form of pickup is strongly directional; if you suspect it is giving trouble, you can try turning the hearing aid. Usually, with hum pickup, you can find a position in which the hum is at a minimum. Most modern hearing aids are designed to avoid this trouble.

In many hearing aids, especially those designed for

higher amplification, the ability to pick up a stray magnetic field is used as a virtue; a special pickup coil is connected so that it may be switched into the amplifier as a substitute for the microphone, and it may be used in place of the microphone to pick up the signal from a telephone receiver. Since it works only on the magnetic field of the receiver, it cuts down markedly on the room noise reaching the hearing aid. Many high-gain hearing aids contain this feature, and you may want to try it.

5. Guidance in Choosing a Hearing Aid

The first step in overcoming loss of hearing is to determine whether the condition responsible for the loss can be remedied or at least checked in its progress by medical treatment. Some causes of conductive loss can be remedied by surgery. The nature of the hearing loss should be found in order to know whether the loss can be compensated by a hearing aid. For the answers to these questions a physician, preferably an ear specialist, should be consulted.

If medical examination indicates that a hearing aid will be helpful, the next problem is the selection of the instrument. Numerous makes are on the market, offering a wide variety of choices. Most manufacturers offer two or more models. Some dealers undertake to provide assistance in the selection of a particular model (from among their own instruments) by methods more or less similar to those outlined in the previous section.

A person shopping for a hearing aid may find it helpful to take with him a person with normal hearing so that, as he tries out different instruments, he may listen to words spoken by the same person. The prospective user should if possible try out one or more hearing aids in his own ordinary surroundings. Some companies provide a trial plan, occasionally charging a nominal rental that may be applied to the price of the instrument if it is purchased.

Hearing aids are designed to be worn as inconspicuously as possible. For people with mild and moderate losses, instruments may be made so small that they can be worn on the head in some way. They are sometimes concealed in the frames of spectacles, with only a plastic tube leading from the earphone to the earmold. (This may make it inconvenient to wipe the lenses because it becomes necessary to detach the hearing aid from the ear.) Over-the-ear hearing aids are very commonly used, and have the advantage of being inconspicuous, without being bound to the eyeglasses. For mild losses, a small hearing aid can be built directly into an earmold.

These head-worn aids have certain acoustical advantages. There is no clothing noise produced. The instrument is not muffled by clothing, and the listener can rotate his head to receive the best sound, just as he could if he were not wearing a hearing aid. Some compromises in sound quality must be made because of the small size of these types of hearing aids. The use of plastic tubing to conduct sound to the ear produces an irregular frequency response characteristic. However, the good points of head-worn hearing aids make them worth consideration by many people.

If the hearing loss is severe, a body-worn hearing aid is necessary. The better sound quality that is possible because of the external earphone and larger size often makes them desirable for other degrees of loss, also. Elderly persons find them easier to operate than a head-worn aid. When comparing a body-type aid with a head type, the body instrument should be placed in the pocket or under the clothing, just as it will be in actual use.

Some persons are made self-conscious by the visibility of their hearing aids. However, some users report that the hearing aid is helpful even when it is not turned on. Conscientious speakers tend to be more careful of their diction when reminded that a communication problem exists. In any case, when a person is observed to take part in a conversation with ease, few persons continue to be aware of how the process is achieved, just as many of us are not sure of which of our friends wear eye glasses.

If you wish to obtain the best possible hearing, make your selection on the basis of performance and not merely on cosmetic appeal. However, do consider that the hearing aid is worn continuously for a long time, and consider how comfortable it feels.

A convenient pocket-sized pamphlet "Choosing a Hearing Aid" has been published by the Children's Bureau, U. S. Department of Health, Education and Welfare. It is listed as Children's Bureau Folder No. 55-1965 and can be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. The price is 15 cents (stamps not accepted). You may find it useful to carry with you as a pocket memorandum.

After the hearing aid is selected, there is often the problem of indoctrination and of learning to make the best use of the hearing aid. This problem may be severe if the user has waited so long before purchasing a hearing aid that he has begun to forget what voices and noises really sound like and how noisy the world is. Also he may have waited until he is too old to learn readily how to adapt himself to a new device. The quality of speech heard through a hearing aid may differ from that to which he has become accustomed. The transition may be considerably helped by wearing the instrument for only an hour or two each day at first and by some systematic "auditory training" or practice in listening.

To assist the hard of hearing in some of these problems a number of "hearing centers" have been established throughout the country. Most of them are nonprofit civic enterprises under the auspices of local universities or hospitals; frequently a nominal fee for their services is charged to those who can pay it.

These centers provide a variety of services, including in many cases advice on the selection of hearing aids. Practically all of them give hearing tests. Many offer otological examination by an ear specialist, and the majority provide other forms of assistance such as auditory training, lip reading, speech training, and vocational counseling.

The hearing centers that offer demonstrations of hearing aids give prospective users an opportunity to try the types they have. Manufacturers are invited to submit instruments representing their current models, and although not all manufacturers are represented a wide variety of makes is usually available. This program has been assisted by a number of manufacturers and dealers who have supplied hearing aids voluntarily to the hearing centers. Partly because hearing centers cannot provide samples of all makes of hearing aids, they cannot be sure of guiding a person to the hearing aid best suited for him, but can give him a general idea of the compensation provided by hearing aids of various types. The centers do not sell hearing aids; an individual goes to commercial sources of supply to purchase his own instrument.

The Professional Services Board of the American Boards of Examiners in Speech Pathology and Audiology registers clinical facilities which meet minimum professional standards in this field. A list of registered clinical facilities, as well as the criteria used in their evaluation, may be obtained by writing to the American Boards of Examiners in Speech Pathology and Audiology, 9030 Old Georgetown Road, Washington, D. C. 20014.

For convenience, a partial list of clinical services is contained in appendix II.

6. Care of a Hearing Aid

A hearing aid is somewhat different from other devices that a person uses in his daily life, and a small amount of special care in handling it may pay substantial dividends in increased usefulness and better performance. The sensitive element in some amplifiers is injured by exposure to high temperatures, and will be ruined permanently by temperatures above 120°F. Such temperatures may be produced locally if the aid is left lying in the sun, in a closed parked car, or too near a radiator. In several instruments these components are made of special high-temperature materials. However, batteries also deteriorate more rapidly at elevated temperatures. For such reasons, it is well to protect aids from extremes of temperature.

The electrolyte in the batteries is either a moderately strong acid or a strong alkali and may cause damage if the battery cases leak. This is likely to happen when the battery is run down. For this reason, it is advisable to separate the battery from the instrument when it is not being worn, especially if the battery is mounted in the amplifier case. Since the battery case is consumed in the chemical process that produces electricity in the battery, usually it is not practical to recharge the batteries. Although this is suggested sometimes as an economy measure, the probability of leakage or bursting is greatly increased because the case material is not renewed by recharging. There are some cells on the market designed for recharging. They are true storage batteries and are usually somewhat more expensive on initial purchase than dry-cell batteries. Rechargeable nickel-cadmium cells are available in sizes that fit ordinary dry-cell mountings. Their life per discharge is approximately one-third that of a dry-cell but they are rechargeable for a large number of cycles.

The Bureau acknowledged "the assistance and suggestions provided by the National Research Council's Committee on Hearing, the Volta Bureau, the American Hearing Society, the Audiology and Speech Correction Center at Walter Reed Hospital, and many interested individuals" in the Preface to Circular 516. Again, we are indebted to our many friends, among whom we should like to mention: the American Speech and Hearing Association, the Alexander Graham Bell Association for the Deaf, the National Association of Hearing and Speech Agencies (formerly the American Hearing Society), and the Committee on Hearing and Bioacoustics of the National Academy of Sciences.

7. Appendix I

The committee on Conservation of hearing of the American Academy of Ophthalmology and Otolaryngology recommends the division of the handicap of hearing into classes or grades, according to the accompanying table. The over-all handicap of impaired hearing is best estimated in terms of ability to hear everyday speech well enough to understand it, but for statistical purposes the more precise measurements of pure-tone audiometry are preferable.

Each class shown in table 2 is defined in terms of the average hearing threshold level for three audiometric frequencies that are important for the understanding of speech.

Editor's Note:

The symbol ISO stands for the threshold standards set by the International Standards Organization. These correspond to somewhat more acute hearing as a norm than do the standards of normal threshold of hearing previously current in the United States. For audiometers standardized against the older U.S. standards (often abbreviated ASA for the American Standards Association), the corresponding hearing loss levels are approximately 10 dB less at frequencies of 500, 1000, and 2000 Hz. An example of this situation is as follows: A person whose hearing threshold averaged for the frequencies 500, 1000, and 2000 Hz is 50 db (ASA) would have the same degree of hearing loss as a person whose hearing loss was 60 dB (ISO). To translate the categories listed in this table for the audiograms obtained with instruments adjusted to the older ASA standards, subtract 10 dB from each of the category boundaries. (The standards have changed; the diagnosis has not.) Ultimately, it is expected that audiometers will be referred to the ISO norms, but at present the changeover is not near completion.

TABLE 2. *Classes of hearing handicap*

(ISO—1964)

dB	Class	Degree of Handicap	Average Hearing Threshold Level for 500, 1000 and 2000Hz in the Better Ear*		Ability to Understand Speech
			More Than	Not More Than	
	A	Not significant		25 dB (ISO)	No significant difficulty with faint speech.
25	B	Slight Handicap	25 dB (ISO)	40 dB	Difficulty only with faint speech.
40	C	Mild Handicap	40 dB	55 dB	Frequent difficulty with normal speech.
55	D	Marked Handicap	55 dB	70 dB	Frequent difficulty with loud speech.
70	E	Severe Handicap	70 dB	90 dB	Can understand only shouted or amplified speech.
90	F	Extreme Handicap	90 dB		Usually cannot understand even amplified speech.

*Whenever the average for the poorer ear is 25 dB or more greater than that of the better ear in this frequency range, 5 dB are added to the average for the better ear. This adjusted average determines the degree and class of handicap. For example, if a person's average hearing threshold level for 500, 1000, and 2000 Hz is 37 dB in one ear and 62 dB or more in the other his adjusted average hearing threshold level is 42 dB and his handicap is Class C instead of Class B.

Appendix II. Hearing Centers

The following list of hearing centers has been compiled from a current list supplied by the National Association of Hearing and Speech Agencies, supplemented by our own correspondence. This list is of necessity incomplete, but it is included as an aid to the reader.

The American Speech and Hearing Association publishes a list of more than 900 sources of speech and hearing clinical services in a "Guide to Clinical Services in Speech Pathology and Audiology." A copy of this Guide may be obtained by writing to the American Speech and Hearing Association, 9030 Old Georgetown Road, Washington, D. C. 20014. Other lists of facilities may be obtained from the Volta Bureau, 1537 35th Street, N.W., Washington, D. C. 20007, The National Society for Crippled Children and Adults, 2023 West Ogden Avenue, Chicago, Illinois 60612, and the National Association of Hearing and Speech Agencies, 919 18th Street, N.W., Washington, D. C. 20006.

The Veterans Administration maintains, at present, a testing program for use in purchase of hearing aids. The tests cover a relatively limited range of instruments. However, if an instrument you are considering for selection happens to be included in the VA program, you may be able to make use of its annual report. The 1970 issue is priced $2.50, available from the Superintendent of Documents, U.S. Government Printing Office. It is titled "Hearing Aid Performance Measurement Data and Hearing Aid Selection Procedures, Contract Year 1970."

ALABAMA

Speech and Hearing Clinic
Auburn University
Auburn, Alabama 36830

Medical College of Alabama
1919 7th Avenue, S.
Birmingham, Alabama 35233

Speech and Hearing Department
Huntsville Rehabilitation Center
316 Longwood Drive
Huntsville, Alabama 35801

Speech and Audiology Department
Mobile Rehabilitation Center
1874 Pleasant Avenue
Mobile, Alabama 36607

Speech and Hearing Clinic
Alabama College
306 Oak Street
Montevallo, Alabama 35115

Central Alabama Rehabilitation Center
Speech and Hearing Department
2125 E. South Blvd.
Montgomery, Alabama 36111

Northeast Alabama Rehabilitation Center
E. Avalon Avenue
Muscle Shoals City, Alabama 35662

Alabama Institute for Deaf & Blind
Comprehensive Center
Dowling Hospital
205 East South Street
P. O. Box 268
Talladega, Alabama 35160

Speech and Hearing Center
P. O. Box 1965
University of Alabama
University, Alabama 35486

ARIZONA

Arizona State University
Tempe, Arizona 85281

Department of Speech
University of Arizona
College of Fine Arts
Tucson, Arizona 85721

ARKANSAS

Arkansas State Teachers College
Conway, Arkansas 72032

CALIFORNIA

Kern County Hospital
1830 Flower Street
Bakersfield, California 93305

Chico State College
1st and Normal
Chico, California 95926

Rancho Los Amigos Hospital
Downey, California 90240

Glendale Hearing Society
1041 North Glendale Avenue
Glendale, California

Inglewood Hearing Society
12419 Menlo
Hawthorne, California 90250

Audiology and Speech Clinic
White Memorial Medical Center
304 N. Boyle Avenue
Los Angeles, California 90033

Beverly-Hollywood Hearing Society
3770 Tracy Street
Los Angeles, California 90027

California State College at Los Angeles
5151 State College Drive
Los Angeles, California 90032

Children's Hospital of Los Angeles
4614 Sunset Blvd.
Los Angeles, California 90027

Department of Eye, Ear, Nose, Throat and Dentistry
1322 North Vermont Avenue
Los Angeles, California 90027

HEAR Foundation of Los Angeles
4507 York Blvd.
Los Angeles, California 90041

John Tracy Clinic
806 W. Adams Blvd.
Los Angeles, California 90007

Los Angeles Co. General Hospital
1200 N. State Street
Los Angeles, California 90033

Los Angeles Eye and Ear Hospital
500 S. Lucas Avenue
Los Angeles, California 90017

Los Angeles Society for Hard of Hearing, Inc.
1660 Arlington Avenue
Los Angeles, California 90019

Speech and Hearing Clinic
University of Southern California
Kerckhoff Hall
734 W. Adams Blvd.
Los Angeles, California 90007

University of Southern California
1200 N. State Street
Los Angeles, California 90033

Children's Hospital Medical Center of Northern California
51st & Grove Streets
Oakland, California 94609

Stanford University
School of Medicine
300 Pasteur Drive
Palo Alto, California 94304

Mt. Diablo Therapy Center
100 Golf Club Road
Pleasant Hill, California 94523

Pomona Valley Hearing Society, Inc.
1139 N. Garey Avenue
Pomona, California 91767

Southern California Hearing Council
21322 Hipass Drive
Pomona, California 91766

University of Redlands
Redlands, California 92373

Sacramento Hearing Society
5275 - F Street
Sacramento, California 95819

HEAR Foundation of San Bernardino
3rd & E Streets
San Bernardino, California 92401

San Diego Speech and Hearing Center
8001 Frost Street
San Diego, California 92123

San Francisco Hearing & Speech Center
2340 Clay Street
San Francisco, California 94115

San Francisco Hearing Society, Inc.
1428 Bush Street
San Francisco, California 94109

Communication Disorders Clinic
San Francisco State College
1600 Holloway Avenue Ed 101
San Francisco, California 94132

University of California Medical Center
3rd & Parnassus Streets
San Francisco, California 94122

San Jose Hearing Society
1403 Kiner Street
San Jose, California 95125

San Jose State College
San Jose, California 95114

Orange County Hearing Society
1209 North Broadway
Santa Ana, California 92701

HEAR Foundation of Tri-Counties
1235 Veronica Spr. Rd.
Santa Barbara, California 93103

University of California at Santa Barbara
Santa Barbara, California 93016

Santa Cruz Hearing Society
Box 304
Santa Cruz, California 95060

Speech & Hearing Clinic
Stanford Medical Center
300 Pasteur Drive
Stanford, California 94305

University of Pacific
3601 Pacific
Stockton, California 95204

HEAR Foundation of Tulare County
115 W. Main
Visalia, California 93277

Whittier College
525 Olive
Whittier, California 90605

COLORADO

University of Colorado
930 Broadway
Boulder, Colorado 80302

Colorado Hearing Society, Inc.
1375 Delaware
Denver, Colorado 80204

University of Colorado Medical School
4200 E. 9th Avenue
Denver, Colorado 80220

University of Denver
Hearing Clinic
2065 South York
Denver, Colorado 80210

Colorado State College
Greeley, Colorado 80631

Speech and Hearing Services
Curative Work Shop Society
10th and West Streets
Pueblo, Colorado 81003

CONNECTICUT

Speech and Hearing Clinic
85 Park Avenue
Bridgeport, Connecticut 06604

Greenwich Hospital
Greenwich, Connecticut 06830

Hartford Hospital
Retreat Avenue
Hartford, Connecticut 06103

Hearing and Speech Center
Yale-New Haven Hospital
789 Howard Avenue
New Haven, Connecticut 06504

New Haven Hearing & Speech Center
100 York Street
New Haven, Connecticut 06516

New Haven Hearing League
378 Congress Avenue
New Haven, Connecticut 06519

Newington Hospital for Crippled Children
181 Cedar Street
Newington, Connecticut 06111

University of Connecticut
Storrs, Connecticut 06268

Hartford Hearing League, Inc.
10 North Main Street
West Hartford, Connecticut 06107

DELAWARE

Audiology & Speech Center
Delaware Division
Wilmington Medical Center
Wilmington, Delaware 19899

League for Hearing Impaired Children
Box 644
Wilmington, Delaware 19899

DISTRICT OF COLUMBIA

Audiology and Speech Center
Walter Reed Army Hospital
Washington, D. C. 20012

Audiology Clinic
Gales Health Center
65 Massachusetts Avenue, N.W.
Washington, D. C. 20001

The Catholic University of America
7th & Michigan Avenue, N.E.
Washington, D. C. 20017

Children's Hospital of D. C.
2220 11th Street, N.W.
Washington, D. C. 20001

D. C. General Hospital
19th St. & Mass. Ave.
Washington, D.C. 20003

Georgetown University Medical Center
3800 Reservoir Road
Washington, D. C. 20007

Hearing and Speech Center
Gallaudet College
Florida Ave. at 7th NE
Washington, D. C. 20002

Speech-Hearing Language Center
Crippled Children's Service
D. C. General Hospital
2215 Independence Avenue, S.E.
Washington, D. C. 20003

Speech and Hearing Center
Washington Hospital Center
110 Irving Street, N.W.
Washington, D. C. 20010

Washington Hearing Society
1934 Calvert St., NW
Washington, D. C. 20009

FLORIDA

University of Miami
Coral Gables, Florida 33134

Hearing Society Volusia County
Box 1085
Daytona Beach, Florida 32019

Speech and Hearing Clinic
University of Florida
Gainesville, Florida 32601

Univ. of Florida Medical School
Department of Communicative Disorders
Gainesville, Florida 32603

Speech and Hearing Center, Inc.
625 Ocean Street
Jacksonville, Florida 32201

Hearing & Speech Center of Florida, Inc.
1540 W. Flagler Street
Miami, Florida 33135

Univ. of Miami, School of Medicine
1700 N.W. 10th Ave.
Miami, Florida 33152

Sarasota Hearing Society
1224 So. Tamiami Trail
Sarasota, Florida 33579

Florida School for the Deaf & the Blind
P. O. Box 1221
St. Augustine, Florida 32084

Jr. Service League, Speech & Hearing Clinic
P. O. Box 244
St. Augustine, Florida 32084

Florida State University
Tallahassee, Florida 32306

Curtis Hixon Rehabilitation Center
Tampa General Hospital, Davis Is.
Tampa, Florida 33606

Tampa Oral School for the Deaf, Inc.
P. O. Box 10706
Tampa, Florida 33609

GEORGIA

University of Georgia
Athens, Georgia 30601

Atlanta Speech School
3160 Northside Parkway, N.W.
Atlanta, Georgia 30327

Davison School of Speech Correction
1780 N. Decatur Road, NE
Atlanta, Georgia 30307

Easter Seal Rehab. Center
1362 W. Peachtree, N.W.
Atlanta, Georgia 30309

Emory University
Speech School
2020 Peachtree Road, N.W.
Atlanta, Georgia 30309

Emory University Clinic
Section of Audiology
1365 Clifton Road, N.E.
Atlanta, Georgia 30322

Augusta Speech and Hearing Center
University Hospital
Augusta, Georgia 30902

Glynn Speech and Hearing Center
1803 Gloucester Street
Brunswick, Georgia 31520

Central Georgia Speech & Hearing Center
514 First Street
Macon, Georgia 31201

Moultrie Speech & Hearing Center
901 Fifth Street, S.W.
Moultrie, Georgia 31768

Savannah Speech and Hearing Clinic
1206 East 66th Street
Savannah, Georgia 31404

Valdosta Speech and Hearing Clinic
1115 North Ashley
Valdosta, Georgia 31601

IDAHO

Hearing and Speech Dept.
Idaho Society for Crippled Children
128 South 5th
Boise, Idaho 83702

Speech & Hearing Clinic
Idaho State University
Pocatello, Idaho 83201

ILLINOIS

Southern Illinois Univ.
WHAM Education Bldg.
Carbondale, Illinois 62901

Speech and Hearing Clinic
Southern Illinois Univ.
Carbondale, Illinois 62901

Warren G. Murray Children Center
Centralia, Illinois 62801

Hearing Clinic
University of Illinois
322 Illini Hall
Champaign, Illinois 61820

Audiology Service
Children's Memorial Hospital
2300 Children's Plaza
Chicago, Illinois 60614

Auditory Research Laboratory
Northwestern University
303 East Chicago Avenue
Chicago, Illinois 60611

Chicago Hearing Society
30 W. Washington St.
Chicago, Illinois 60602

Michael Reese Hospital
Henner Speech & Hearing Center
2929 S. Ellis Ave.
Chicago, Illinois 60616

Section of Otolaryngology
Department of Surgery
University of Chicago
Chicago, Illinois 60637

Speech and Hearing Clinic
Presbyterian St. Luke's Hospital
1753 W. Congress Parkway
Chicago, Illinois 60612

Speech & Hearing Clinic
Schwab Rehabilitation Center
1409 So. California
Chicago, Illinois 60608

Speech & Hearing Clinic
St. Josephs Hospital
2900 N. Lakeshore Dr.
Chicago, Illinois 60657

Speech and Hearing Rehabilitation Clinic
Univ. of Illinois
904 W. Adams St.
Chicago, Illinois 60607

Speech and Hearing Station
Communicative Processes Study Center
University of Illinois at the Medical Center
1855 West Taylor Street
Chicago, Illinois 60612

Speech and Hearing Clinic
Northern Illinois Univ.
DeKalb, Illinois 60115

Elmhurst College
190 Prospect Ave.
Elmhurst, Illinois 60126

Eastern Illinois Univ.
Evanston, Illinois 61920

Northwestern University Hearing Clinics
Speech Annex
Evanston, Illinois 60201

MacMurray College
Jacksonville, Illinois 62650

College of St. Francis
500 Wilcox St.
Joliet, Illinois 60435

Lincoln State School
Hearing and Speech Dept.
861 So. State St.
Lincoln, Illinois 62656

Speech & Hearing Clinic
Fairchild Hall 205
Illinois State Univ.
Normal, Illinois 61761

Speech and Hearing Clinic
Bradley Univ.
815 Glenwood
Peoria, Illinois 61606

Rockford College
Speech Department
5050 E. State
Rockford, Illinois 61101

The Winnetka Inst. for Hearing and Speech
614 Lincoln Avenue
Winnetka, Illinois 60093

INDIANA

Clinical Audiology Lab.
Speech and Hearing Center
Indiana Univ.
Bloomington, Indiana 47401

Gary Hearing Society
225 Joliet Street
Dyer, Indiana 46311

Tri-State Hearing & Speech Assn.
3701 Bellemeade Ave.
Evansville, Indiana 47715

Community Coordinating Center for Rehabilitation & Health Service
227 East Washington St.
Fort Wayne, Indiana 46802

Fort Wayne Hearing Society
1027 E. Wayne St.
Fort Wayne, Indiana 46802

Trade Winds Rehab. Center
5901 W. 7th Ave.
Gary, Indiana 46406

Audiology & Speech Clinic
Indiana University Medical Center
Indianapolis, Indiana 46202

Indiana School for the Deaf
1200 E. 42nd Street
Indianapolis, Indiana 46205

Indianapolis Speech & Hearing Center
615 North Alabama St.
Indianapolis, Indiana 46204

Speech & Hearing Clinic
Purdue Univ.
LaFayette, Indiana 47907

Hearing & Speech Center of St. Joseph Co.
208 North Ironwood
Mishawaka, Indiana 46544

Speech & Hearing Clinic
Ball State Univ.
Muncie, Indiana 47306

Indiana State Univ.
Terre Haute, Indiana 47809

Purdue Univ.
West Lafayette, Indiana 47907

IOWA

Cedar Rapids Hearing Society
615 - 30th Street, S.E.
Cedar Rapids, Iowa 52403

State College of Iowa
Cedar Falls, Iowa 50613

Iowa School for the Deaf
Council Bluffs, Iowa 51501

Des Moines Hearing & Speech Center
700 Sixth Ave.
Des Moines, Iowa 50309

See-Hear Organization, Inc.
P. O. Box 505
Dubuque, Iowa 52001

Grinnell College
Park Street
Grinnell, Iowa 50112

Division of Speech and Hearing
Department of Otolaryngology and Maxillofacial Surgery
University Hospitals
Iowa City, Iowa 52240

State Univ. of Iowa
308 Melrose Avenue
Iowa City, Iowa 52240

University of Iowa Speech and Hearing Clinic
Wendell Johnson Speech and Hearing Center
Iowa City, Iowa 52240

Speech & Audiology Department
Siouxland Rehabilitation Center
406 29th Street
Sioux City, Iowa 51104

Exceptional Persons, Inc.
1028 Headford, Box 690
Waterloo, Iowa 50701

KANSAS

Ft. Hays Kansas State College
Hays, Kansas 67602

Kansas Univ. School of Medicine
Dept. of Otolaryngology
39th & Rainbow
Kansas City, Kansas 66103

University of Kansas
4 Bailey Hall
Lawrence, Kansas 66045

Kansas State University
Manhattan, Kansas 66045

Parsons State Hospital & Training Center
Parsons, Kansas 67357

Department of Logopedics
Wichita State Univ.
Wichita, Kansas 67219

KENTUCKY

University of Kentucky
Taylor Education Bldg.
Lexington, Kentucky 40503

Kentucky Society for Crippled Children
233 E. Broadway
Louisville, Kentucky 40202

Louisville General Hospital
Louisville, Kentucky 40202

LOUISIANA

Baton Rouge Speech & Hearing Foundation
574 W. Roosevelt Street
Baton Rouge, Louisiana 70802

Speech & Hearing Clinic
Music & Dramatic Arts Building
Louisiana State Univ.
Baton Rouge, Louisiana 70803

Univ. of SW Louisiana
Box 80, University Station
Lafayette, Louisiana 70501

Crippled Children's Hospital
200 Henry Clay Avenue
New Orleans, Louisiana 70118

Department of Otorhinolaryngology
LSU School of Medicine
1542 Tulane Avenue
New Orleans, Louisiana 70112

New Orleans Speech and Hearing Center
1636 Toledano
New Orleans, Louisiana 70115

Tulane Speech & Hearing Center
Tulane Medical School
1430 Tulane Avenue
New Orleans, Louisiana 70112

Louisiana Polytechnic Institute
Ruston, Louisiana 71270

MAINE

Bangor Regional Speech and Hearing Center
142 Pine Street
Bangor, Maine 04401

Northeast Hearing & Speech Center, Inc.
690 Congress Street
Portland, Maine 04102

MARYLAND

Hearing & Speech Agency of Metro. Baltimore, Inc.
938 North Charles Street
Baltimore, Maryland 21201

Hearing and Speech Center
Johns Hopkins Hospital
601 N Broadway
Baltimore, Maryland 21205

Univ. of Maryland, School of Medicine
Greene & Lombard Sts.
Baltimore, Maryland 21201

University of Maryland
College Park, Maryland 20742

MASSACHUSETTS

Boston Guild for the Hard-of-Hearing
283 Commonwealth Ave.
Boston, Massachusetts 02115

Boston Univ. Medical Center
55 Stoughton Street
Boston, Massachusetts 02118

Harvard Univ. Medical School
243 Charles St.
Boston, Massachusetts 02114

Department of Otolaryngology
University Hospital
750 Harrison Ave.
Boston, Massachusetts 02118

Tufts Medical School
185 Harrison Avenue
Boston, Massachusetts 02111

Winthrop Foundation & Clinic for the Deaf
Massachusetts Eye & Ear Infirmary
243 Charles St.
Boston, Mass. 02114

Billerica Hearing & Speech Society
117 Gray Street
East Billerica, Massachusetts 01821

The Franklin Co. Hearing & Speech Center, Inc.
278 Main St., Room 407
Greenfield, Massachusetts 01301

Springfield Hearing & Speech Center, Inc.
77 Maple Street
Springfield, Massachusetts 01105

Worcester County Hearing
306 Main St.
Worcester, Mass. 01608

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Detroit, Michigan 48202

Wayne State University
261 Mack Blvd.
Detroit, Michigan 48201

Detroit Hearing and Speech
1401 Ash Street
Detroit, Michigan 48208

Department of Audiology & Speech Sciences
Michigan State University
East Lansing, Michigan 48823

Lansing Society for Better Hearing
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East Lansing, Michigan 48823

Michigan Association for Better Hearing
724 Abbott Road
East Lansing, Michigan 48823

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2522 Landon
Flint, Michigan 48504

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Grand Rapids, Michigan 49507

Jackson Society for Better Hearing
141 Baits Street
Jackson, Michigan 49262

Constance Brown Hearing & Speech Center
301 West Cedar Street
Kalamazoo, Michigan 49006

Kalamazoo Society for Better Hearing
301 West Cedar Street
Kalamazoo, Michigan 49006

Speech and Hearing Clinic
Western Michigan University
Kalamazoo, Michigan 49001

Hearing & Speech Department
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Lansing, Michigan 48910

Western Michigan Society for Better Hearing
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Ludington, Michigan 49431

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1605 State St.
Midland, Michigan 48640

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Central Michigan University
Mount Pleasant, Michigan 48858

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425 Lyman Building
Muskegon, Michigan 49441

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Owosso, Michigan 48867

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Burns Clinic
Petoskey, Michigan 49770

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201 East 10th
Traverse City, Michigan 49684

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Minneapolis, Minnesota 55404

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Minneapolis, Minnesota 55400

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Audiological Section
Rochester, Minnesota 55901

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444 Lowry Medical Arts Building
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496 Endicott-on-Robert Building
St. Paul, Minnesota 55114

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Columbus, Mississippi 39701

Speech and Hearing Clinic
University of Southern Mississippi
Hattiesburg, Mississippi 39401

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Warrensburg, Missouri 64093

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Missoula, Montana 59801

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Lincoln, Nebraska 68508

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Omaha, Nebraska 68108

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602 S. 44th Ave.
Omaha, Nebraska 68115

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Omaha, Nebraska 68105

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Greenfield, New Hampshire 03047

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Jersey City, New Jersey 07306

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Montclair, New Jersey 07042

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Newark, New Jersey 07102

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Newark, New Jersey 07104

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Paterson, New Jersey 07505

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Plainfield, New Jersey 07060

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Union, New Jersey 07083

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Upper Montclair, New Jersey 07043

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Albuquerque, New Mexico 87108

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Albuquerque, New Mexico 87106

University of New Mexico
Central Ave., N.E.
Albuquerque, New Mexico 87106

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Santa Fe, New Mexico 87501

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Binghamton, New York 13901

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Bedford Ave. & Ave. H.
Brooklyn, New York 11210

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Brooklyn, New York 11238

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Brooklyn, New York 11203

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Brooklyn, New York 11201

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Brooklyn, New York 11203

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Buffalo, New York 14209

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Buffalo, New York 14214

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Queens College of CUNY
Flushing, New York 11367

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Flushing, New York 11355

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Long Island,
Greenvale, New York 11548

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New Hyde Park, New York 11040

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New York, New York 10003

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Cleveland, Ohio 44106

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313 Sixth Avenue
Pittsburgh, Pennsylvania 15222

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Reading, Pennsylvania 19603

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West Chester, Pennsylvania 19380

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West Reading, Pennsylvania, 19602

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Memphis, Tennessee 38105

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Library Road
Pullman, Washington 99163

Seattle Hearing & Speech Center, Inc.
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Seattle, Washington 98122

Speech and Hearing Clinic
University of Washington
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Seattle, Washington 98105

Inland Speech and Hearing Center
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East 618 - 21st Ave.
Spokane, Washington 99203

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Charleston, West Virginia 25304

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Morgantown, West Virginia 26506

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Marchfield, Wisconsin 54449

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8700 West Wisconsin Avenue
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744 N. 4th Street
Milwaukee, Wisconsin 53203

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